# SCIENCE

VOL. LXXII FRIDAY, NOVEMBER 7, 1930 No. 1871



SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

# NATURE AND FATE OF THE METEOR CRATER BOLIDE

By Emeritus Professor HERMAN L. FAIRCHILD

UNIVERSITY OF ROCHESTER

THE impact origin of Meteor Crater, Arizona, is an accepted fact. The fate or disposition of the colliding body is yet undetermined, and a very interesting problem in cosmic science.

Through many years of exploration, with large expense, the Barringers, father and sons, have collected and published a mass of surprising facts about the crater and its associated meteoric materials. The data, however, have not been marshaled to attack the question of what has become of the greater part of the meteor, except to sustain the theory that the mass lies buried under the south wall of the crater.[1]

The problem of the fate of the meteor involves not only the physical and chemical properties of the discovered meteor fragments but the nature of other meteorites. There are also involved most of the features of the crater and the characters of the rock strata which were disrupted.

## CANYON DIABLO SIDEROLITES

The meteoric irons known as Canyon Diablo, from the near-by creek and canyon, have been gathered from the desert plain about the crater to the number of thousands and distributed to institutions all over the world. Because of their number and wide distribution, their inclusion of minute diamonds, their genetic relation to the unique crater and their remarkable chemical and physical characters they are the most interesting and instructive of known meteorites. The facts concerning these irons should give some clue to the character and fate of the giant bolide of which they were a part.

The typical C. D. irons were scattered over the des-

[1] See article by D. M. Barringer, Jr., in the *Scientific American* of July, August and September, 1927. A list of the more important writings is given in SCIENCE, 69: 485–487, 1929.

ert in a radius of four miles and have also been found in the ejecta on the rim of the crater. The largest one weighed about 1,400 pounds. The total weight of all the discovered irons can be only several tons, and they are certainly only a small percentage of the giant bolide. On the supposition that the meteor was wholly nickeliferous iron ballistic calculations have suggested a diameter of about 400 feet and a weight of some ten million tons. The velocity factor, against which the mass must be computed, is unknown. The facts to be described below do not favor a meteor composed wholly of iron.

### Exploration—the Rock Strata

The early exploration of the crater assumed that the meteor lay buried under the ninety feet of lacustrine sediment in the floor of the crater and in the subjacent rock débris. After a shaft was found impracticable, because of the copious ground water, drilling was done during the years 1905–1908. Only particles of nickel-iron and some green stain of nickel were found by the drills. But an important discovery was that the deeper rock strata were in continuous and undisturbed position. This ruled out any idea of a volcanic vent or chimney.

The rocks of the region belong in the Grand Canyon Series. They are as follows, in descending order.

(1) On the desert plain, some remnants of the red Triassic sandstone, called Moencopie.

(2) The topmost continuous stratum is the Kaibab, a Permian limestone, 250 feet in thickness.

(3) A white, saccharoidal sandstone, the Coconino; 1,000 feet; also of Permian age. The basal beds of the Coconino carry some yellow and brown color.

(4) Hard, red sandstone, known as the Red Beds, or Supai formation, of undetermined depth in that region.

The central area of the crater was probed by seventeen drill holes, even to the depth of 1,000 feet, or 1,450 feet below the surface of the surrounding plain. This probing passed entirely through the white Coconino sandstone, and penetrated 200 feet into the Red Beds. Seven of the drill holes entered the Red Beds, which were found in place and unchanged. This lowest formation is not represented in the ejected materials composing the crater rim, but samples of the yellow-brown basal rock of the Coconino are found in the ejecta on the southern rim.

During later years, from 1920, exploration has been made on the south border of the crater, on the theory that the bolide fell slantingly from the north and that much of it lies deep under the south wall. This section of the uptilted surrounding rim has been raised about 100 feet higher than elsewhere. The drillers reported meteoric iron from the depth of 1,200 feet down to 1,376 feet, where the drill was stuck and abandoned. Recently a shaft at the locality was a failure because of water and the shattered condition of the rocks. Further exploration is anticipated.

It appears highly improbable, if not impossible, that the mass of the bolide could penetrate to the depth reported for meteoric material. It would have to slantingly traverse some 2,000 feet of rock. And the uplift of the surface should be more than 100 feet. And it is difficult to visualize the mechanics by which detached fragments could reach to the great depth.

### Impact Effects on the Rock Strata

The kinetic energy resident in the meteor was instantly expended in several direct effects, as follows:

(1) Crushing of the rocks beneath the locus of impact. The Kaibab limestone which lay immediately beneath the area of impact must have been pulverized to dust and largely swept away in the steam and dust cloud from the violent explosion described below. The underlying Coconino sandrock was shivered to microscopic dust, and much of it was poured out over the crater rim to help form the encircling hills, also described below.

(2) Shattering of the rocks laterally, with expulsion of the rock strata surrounding the impact area. This is attested by the great volume, with huge blocks, of firm limestone which constitutes a large part of the ring of débris.

(3) Vibratory motion which shivered the sand grains of the Coconino sandstone. This is a most interesting feature which has not been sufficiently emphasized. The elevated rim of the crater, averaging 120 feet high above the plain, appearing from a distance and from the Sante Fe Railroad as a range of low hills, consists of the dislodged Kaibab limestone and the crushed Coconino sandstone. This lower formation was affected to its base and largely reduced to dust. Some portion of the kinetic energy in the colliding body was suddenly changed to short-wave vibrations which shattered the individual sand grains. The resulting dust, of angular, crystalline quartz, is of such microscopic fineness that 55 per cent. will pass a 200-mesh sieve. Masses of the rock which to the eye appear as firm sandstone will crush to powder under hand pressure.

(4) If the meteor was largely brittle material, as will be claimed below, it was also shivered. The matter of temperature applies here; also noted later.

(5) Production of intense heat. Theoretically this was inevitable. Clear evidence is found in masses of the Coconino sandstone altered by fusion to "silica glass" or lechatelierite. This required a temperature of 1,400 to 1,800 degrees Centigrade.[2]

[2] See article by A. F. Rogers, *Amer. Jour. Science*, March, 1930.

Further proof is found in rock fragments that carry brown and green stain from vaporized nickel-iron.

### REACTION AND EXPLOSIVE EFFECTS

The huge crater was the product of mechanical reaction. The expulsion of rock was partly by the elastic reaction of the compressed strata with its included air, but largely from water expansion.

The sudden compression of the rock strata to a depth of 1,250 feet involved the air which was in the upper strata and the water which saturated the deeper strata.

Standing water deposits, ninety feet thick in the crater floor, consist of marl and peat of organic origin and sand and clay washed in from the basin walls by the "cloud-burst" precipitation of the desert climate. The height of the standing water in the basin shows that the strata were filled with air and water to the depth of 450 feet and below that were entirely saturated with water. As disruption of the rock reached to the base of the Coconino sandstone, 1,250 feet below the land surface, it follows that 800 feet of the porous sandrock, the affected thickness below the later lake level, supplied water for the steam explosion.

In his examination of the crater in 1892 Mr. Gilbert recognized the explosion phenomena, but interpreted them as volcanic. It may be noted that if the explosion had been from subterranean heat this would have involved the porous strata far and wide, and hot-water or fumarolic phenomena would have subsequently occurred for, perhaps, centuries.

The elastic rebound of the compressed rocks and the included air, and the explosive expansion of the suddenly generated steam produced enormous mass movement. This was the expulsion of the meteor itself and of rock material to the depth of 540 feet and over an area three fourths of a mile in diameter.

The size of the crater does not directly indicate the size of the bolide. It is a problem of two indeterminate factors, mass and velocity.

### PHYSICAL STATE OF THE METEOR

The temperature of the meteor is a factor of some importance. To the degree that its internal temperature was low the mass was correspondingly brittle, whether iron or mostly stone. If the body had suddenly arrived from extra-solar space, as a casual visitor to our planetary system, it probably had very high velocity, and was intensely cold. And even if it had been aimlessly wandering with some relation to the sun it probably had very low temperature and a velocity not less than that of the observed meteors.

The violent impact which produced so great effect on the earth must have shattered the bolide, whatever its velocity, temperature and substance. If it was largely stony material, as all the facts appear to indicate, the stone was shivered to dust and swept away in a cloud of vapor, in which case only the included, nodular masses of iron-alloy are the existing remnants.

The walls of the crater have receded somewhat under the storm-wash of many centuries, and the débris has produced the talus slopes, giving the concave profile to the basin. The talus and the ninety feet of water deposits have buried any meteor fragments which fell into the basin. But many fragments of the hydrated iron, to be described, have been found in the ring of débris topping the walls. And Brandon Barringer writes that it has been found beneath the talus and against the south wall.

### RELATION OF THE IRONS TO THE PARENT BODY

There is no doubt that the thousands of nickeliferous irons found over the desert were associated with the huge bolide. The question is—how did they acquire such dispersion? Were they detached companions of the main body, or are they projected fragments of the disrupted mass?

Dr. O. C. Farrington writes that some specimens of the C. D. irons in the Field Museum have surface features which prove that they fell as individual units. This would indicate that the great bolide did have some free associates, as might be expected. But the fact that the great majority of C. D. irons have irregular forms, with no surficial features produced by atmospheric friction and heat, argues for their inclusion in other material, either as detachments or as an integral part of the great meteor.

If the C. D. irons found over the desert, through a radial distance of four miles, were loose adherents of the central mass, or if they had become detached by the resistance of the earth's atmosphere, then they formed a group some eight miles in diameter. And as distinct units, with original velocity like that of the parent body, the larger ones, with weight of many hundred pounds, should have produced individual craters or pittings in the ground surface. Furthermore, if the typical C. D. irons were only non-oxidizable portions of once larger masses (as some of them certainly are) such larger bodies would have had even greater energy for production of individual craters. If the great bolide buried itself under 1,400 feet of solid rock then the detached units should have behaved in similar manner. But no such pittings of the desert have been noted. Of course, in time the "cloud-burst" storms and high winds of the desert region would obliterate the pittings by filling and such irons as were imbedded would be entirely or partially buried. But all information is to the effect

that all the thousands of collected irons lay exposed on the open surface of the desert.

In this dilemma one suggestion is that the detached units did not imbed themselves but rebounded from their craters.

The iron nodules which were inclusions in the disrupted bolide, and were projected by the explosive reaction, had momentum only sufficient to carry them, like a shot from a mortar, to their positions on the plain. Fragments of the disrupted rocks are reported to lie two miles from the crater. Unfortunately, no facts are available as to the characters of the irons in relation to their distance from the crater.

### PHYSICAL AND CHEMICAL CHARACTERS OF THE IRONS

The most interesting and important element in this study is the chemical constitution of the irons. Along with the typical C. D. irons there is at least one other variety. The C. D. type is the unoxidizable and resistant irons which have lain on the desert for a great length of time. They are clearly of nodular character. They generally bear no evidence of frictional passage through the air, but do have the surface features, the irregular shapes and the cavities and perforations of nuclei or enclosed accretions. They are the unoxidized and undecomposed segregations out of larger masses of vanished material. The only doubt is whether the enclosing mineral was decomposable iron or was a stony matrix.

The composition of the permanent, D. C. irons is, by percentage: Iron, 92; nickel, 6; some carbon, with minute diamonds; and small amounts of platinum, iridium, palladium, phosphorus, cobalt and copper.

Associated with the easily recognized meteoric irons was a considerable amount of limonite or hydrated iron. During early exploration this was neglected, under supposition that it was derived from the limestone of the desert surface. Barringer noted that larger fragments had a laminated structure and he called it "iron shale." Later, subspherical masses with concentric lamination were found, especially in excavations in hills of débris, and he called these "shale balls." Then it was observed that some of these masses had a green stain, and chemical examination revealed that they contained the nickel and rare elements of the C. D. irons, and, in addition, chlorine.

A specimen of the meteoric iron, supposed to be the typical C. D., in the Meteor Crater exhibit in the University of Rochester Museum in the course of years disintegrated to powder. If this is another variety of the decomposable iron or if it would have produced the "iron shale" form had it been exposed to open weather is unknown. But it emphasizes the perishable nature of some of the meteorites.

Another important discovery is that nodules of the unchangeable or typical C. D. iron are found in the shale balls. Also, that the decomposable, chlorine-bearing iron is occasionally found in the C. D. irons.

The intimate association of decomposable and of permanent iron clearly explains the cavities, holes and perforations in many specimens of the C. D. meteorites. And a similar cause is suggested for the cavities and perforations in the iron meteorites of other finds, for example, the great Willamette, in the American Museum.

### THE ARIZONA BOLIDE A STONY METEOR

The doubt concerning the Meteor Crater visitor is whether it was wholly meteoric iron or was a larger body of stony composition, with iron-alloy inclusions, in other words, was the meteor of iron, with smaller size, of high density and with high velocity, or a larger body of stony substance with iron inclusions, of less density and perhaps with less velocity.

Our ignorance as to the source of meteors and comets does not justify the assumption that great masses of iron alloys, up to 400 feet in dimensions, could not exist, or are not formed in some planetary bodies or in dead suns, or that they may not exist deep within our globe. However, present knowledge of terrestrial and cosmic processes does not suggest the formation of such massive metallic bodies.

The early suggestion that the mass of the bolide might have been mostly stone, instead of metal, has been ignored because no stony material foreign to the local rocks has ever been found, although diligently sought by S. J. Holsinger, who conducted the early studies. But when we recognize the perishable nature of stony meteorites any such material should not have been expected.

The stony meteorites are exceedingly varied and complex in both composition and structure and subject to easy decay by atmospheric agencies. In consequence of this the "finds" of stony meteorites, or their discovery apart from visible "falls," are exceedingly rare. The "finds" are practically all of resistant nickel-iron. In his book on "Meteorites" (1915), Dr. O. C. Farrington states that of 350 falls only ten were of iron. But if the stony meteorites are thirty-five times as numerous as the iron, and yet quite wanting among the finds, it clearly shows their perishable nature. It may also be possible that some of the ten irons included in the 350 falls had quickly lost their brittle and ephemeral matrix before they were located.

The Arizona visitor arrived centuries and perhaps thousands of years ago, and time has been amply sufficient to destroy all the mass except the imperishable iron nodules and some of the chlorine-bearing iron.

It should also be noted that the spasmodic precipitation of the arid region has favored the washing-away of the products of decay, even if this was not all soluble. Doubtless a great quantity of pulverized rock, both limestone and sandstone, was spread widely over the plain. But this has been removed by solution and storm-wash of the torrential rains. The elevated rim of the crater prevented inwash from the surrounding desert.

All the facts concerning the C. D. irons clearly indicate that they were inclusions or nodules of resistant nature, inclosed in some kind of perishable material. And some of that matrix was chlorine-bearing iron.

The rotund or globular form of some of the "shale balls," the decomposable irons, strongly suggests that they also were only concretionary masses in a matrix of other substance. That substance could have been only the stony materials of which most known meteorites are composed. It may not be claimed that because of its greater size the Meteor Crater meteorite was entirely different in source and nature from all other celestial immigrants.

All the facts relating to meteorites in general, and the Meteor Crater bolide in particular, along with the theoretic probabilities, support the view that the Arizona visitor was a very large stony mass with metallic inclusions.

The stony matrix was brittle, even if without very low temperature, and it was shivered by the impact mostly or wholly to dust. And this was thrown high in air, and borne by the steam cloud it was disseminated far and wide, and any large fragments were quickly destroyed by decomposition and hydration.

This conclusion regarding the C. D. irons may imply that many other, if not all, of the known iron meteorites, even the largest, were originally inclusions in perishable matrix. The irregular, angular forms, perforations and characterless surfaces were probably produced by their imbedding as nodules or accretions in other materials. Only the irons which have traversed our atmosphere after losing their protective covering exhibit some frictional and flowage surfaces.

In the above study no estimate has been made as to the kinetic energy resident in the bolide, and the explosive effect has been attributed mainly to the water and air held in the rocks. But if the meteor was large, with high velocity and high density, the impact might have produced sufficient heat to vaporize both the meteor and the crushed rock. And more probably such would have been the case if the bolide was wholly or largely nickel-iron.

In such case the metallic vapor, with terrific expansion in all directions, should have coated all the surviving rocks with a green stain. The absence of such stain is another argument for a stony meteor.

If the meteor was dissipated in vapor then the thousands of C. D. irons found on the desert could not have been part of the main body. With or without enclosing matrix they had become detached from the central mass by atmospheric friction, and so far separated, and perhaps laggard, that they escaped the grand smash-up.

# MICROPHONIC ACTION IN TELEPHONE TRANSMITTERS

By Dr. FREDERICK S. GOUCHER

BELL TELEPHONE LABORATORIES

A MICROPHONE may be defined as a transmitter which makes use of the resistance variation of one of its elements in changing a pressure wave into an electrical one. That element, in the case of our commercial carbon transmitter, is an aggregate of loosely packed carbon granules, which is compressed between the diaphragm and the wall of a cavity in which the granules are held. Other types of transmitters operate in accordance with other principles. Bell's original transmitter, for instance, reversed the action of the present-day receiver and was electromagnetic in its action. The condenser transmitter, now used extensively in the sound picture industry, depends, on the other hand, on changes in capacitance. Neither of these types has the advantage of amplification and high energy output characteristic of the carbon transmitter, and for this reason the latter is used almost exclusively in our present-day telephone system.

Microphonic action as applied to our commercial transmitters has to do then with those physical changes responsible for variations in resistance which take place in the aggregate of granules when this is subjected to variations of stress at audible frequencies. This process is complex, and as yet there has been no experimental demonstration of the precise nature of the changes involved.

## HISTORICAL

An attempt at a quantitative theory of microphonic action was made by Professor P. O. Pedersen.[1] He assumed that microphonic action occurs as a conse-

[1] *Electrician*, February 4, 1916.

quence of the elastic deformation of the contact material resulting in a variation of the contact area. Considering the case of two elastic conducting spheres brought into contact, Pedersen assumed that the resistance is made up of two parts: *viz.* (1) the resistance of a conducting film, the specific resistance of which does not change under pressure, and (2) the so-called "spreading resistance" or that which is caused by the concentration of the current flow within the region of the contact area and which would exist independently of any film.

Using well-known principles of elastic and potential theory, he arrived at the equation

$$R = \frac{A}{(F)^{2/3}} + \frac{B}{(F)^{1/3}} \qquad (1)$$

where R is the contact resistance, A and B are constants and F is the contact force. The first term on the right is the film resistance which is inversely proportional to the contact area and the second term is the "spreading resistance" which is inversely proportional to the radius of the contact area.

Pedersen tested his theory by experiments on carbon spheres and found reasonable agreement over a wide force range. But there were reasons for doubting the existence of the high resistance film. It appeared reasonable to suppose that contact would not take place over the whole contact area owing to surface roughness (the existence of which could be observed under a microscope especially in the case of carbon) and that this roughness would behave somewhat like a high resistance film. F. Gray, of these laboratories,[2] worked out a theory based on this assumption which was so nearly like Professor Pedersen's that it was difficult to discriminate between them experimentally. He assumed that the microscopic hills in electrical contact not only increase in number as the contact force is increased but that the resistance per hill varies in accordance with the theory of spreading resistance as assumed by Pedersen.

Considering the simple case of two spheres having a surface of ideal roughness consisting of smooth spherically convex hills, the radius of curvature of which is small compared with that of the contacting spheres, he arrived at the relation

$$R = \frac{A}{(F)^{7/9}} + \frac{B}{(F)^{1/3}} \qquad (2)$$

The first term on the right shows the effect of the roughness and the second term the effect of the "spreading resistance" which would exist independently of the roughness. This equation differs from Pedersen's only by a factor of $(F)^{-1/9}$ in the first term on the right. Gray also investigated the effect of adding a film to this first order roughness and the effect of adding a second order roughness to the first order roughness and showed that these only serve to modify the equation slightly at small contact forces. A high degree of roughness gives a departure from the inverse 7/9 power law and a transition to the inverse first power law for the case infinite roughness.

Equation (2) was found to fit experimental curves remarkably well at large contact forces and over a very wide range of forces. It thus appeared that surface roughness behaves almost identically with a non-variable high resistance film. Marked departures from theory were found at very small contact forces, the resistance decreasing too rapidly with an increase in contact force. These departures are no doubt associated with plastic deformation of the contact material, as Gray was able to show.

However, the applicability of the theory to contacts between granules of microphone material was left in doubt, not only because the contact forces in this case are smaller—being of the order of 1 dyne—than those for which the theory had been demonstrated to hold, but also because of several effects which indicated that other factors might be dominant in this region of small contact forces.

For instance, it has been demonstrated[3] that adsorbed films of air are capable of producing a marked increase in the resistance of granular carbon contacts. It is reasonable to assume that these films may play some fundamental part not only in the conduction of current across the contact but in the mechanism of resistance change with variation of contact force. The late Emile Berliner, who was responsible for fundamental developments in carbon transmitters, believed that these air films are all important and even went so far as to claim that an actual gap could be observed—by means of a microscope—between contacts while they were transmitting.

Again there is a marked decrease in the resistance of granular carbon contacts with increase in voltage which has not been satisfactorily explained. This fact suggests among other possibilities that the conduction process may involve the passage of electrons across gaps of molecular dimensions in the manner of a cold point discharge; field gradients of sufficient magnitude to extract electrons from a solid could exist in these gaps with only a fraction of a volt across the contacts. If this were the case microphonic action might well be associated with a variation of the gap dimensions under strain.

Another suggestion has been that the resistance change is a strain phenomenon: that is, owing to cohesion, the contacts may be substantially welded to-

[2] *Phys. Rev.*, 36: 375, 1930.

[3] P. S. Olmstead, *Journal of Phys. Chem.*, 33: 69, 1929.

gether and the resistance is changed in much the same manner as that of a wire under tension or that of a solid under hydrostatic pressure. Bridgman has shown that the pressure coefficient of resistance of carbon is negative, so that we might reasonably expect at least part of the decrease in contact resistance with increase of contact force to be due to this cause. At a very early date Edison advanced the hypothesis that microphonic action is due to a change of specific resistance of the material in the contact junction.

### RECENT EXPERIMENTAL WORK[4]

In view of these considerations it appeared very desirable to study the behavior of contacts—particularly those between granules of microphone carbon—under conditions of very small contact force. The work which will here be described has been undertaken with this object in view. A technique has been developed for controlling contact forces of the order of 1 dyne or less, either in the highest vacuum or in any desired gas atmosphere, also for controlling contact temperature over the range of temperatures which, we have reason to believe, covers that which holds for the contacts in a microphone.

The essential features of one of the tubes used in studying these contacts are shown diagrammatically in Fig. 1. The contacts $C_1$ and $C_2$ are fastened respectively to a movable base M and to the lower end of a silica helical spring of suitable stiffness. The base M is supported from a fixed frame F by two vertical platinum wires P and two stretched springs as shown. M is moved by heating or cooling the platinum wires, through the passage of current, thereby causing them to expand or contract. In this way the contacts may be made or broken and any desired contact force applied through the compression of the helical spring. Control of the temperature of the contact is obtained by surrounding the contact region with a metal cylinder S which may be heated by means of radiation from a platinum heater H, the temperature within the cylinder being measured by means of a thermocouple placed near the contacts.

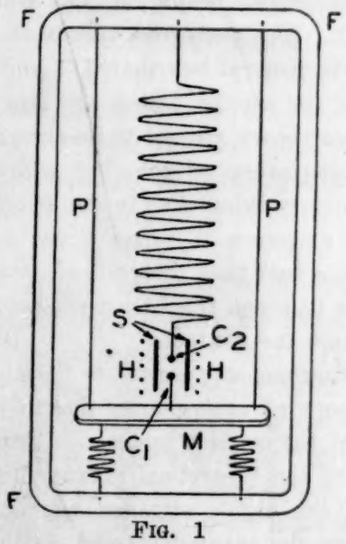

FIG. 1

In practice $C_2$ consists of a single granule fastened to the end of a platinum wire by means of carbon paste, and $C_1$ consists of a number of granules attached to a horizontal metal plate by the same means; in this way a variety of contacts can be studied with the same tube. A small hole in the metal cylinder surrounding the contacts permits of direct observation of the contacts during measurement.

When set up for measurement the tube is suspended by rubber bands within a massive metal container which serves to protect the system from acoustic shock. This container is mounted on a suspension to minimize the effect of vibrations. Two reading telescopes are mounted in the side of the container for the purpose of measuring the spring compression, the lower one being focused directly on the contact.

Measurements made with this device have enabled us to draw a number of conclusions in regard to the nature of these contacts and their behavior when the contact force is varied.

In the first place, we have identified the conducting portions of the contacts as of the nature of carbon by means of measurements on the temperature coefficients of resistance of contacts. It is well known that the temperature coefficient for carbon is negative—as opposed to a positive value for most conductors—and the magnitude of this coefficient for the contacts was found to be of the right order and sign for solid carbon, prepared by special heat treatment. The value of the contact temperature coefficient may be modified by heat treatment of the carbon which probably does not affect its interior so that we have reason for believing that the surface material is a somewhat different carbon from that inside.

The magnitude of the temperature coefficient of resistance was found to be independent of gas pressure even though the presence of gas increased the contact resistance. The gas therefore must act as a non-conducting film limiting the areas of the conducting portions of the contact and not affecting their nature.

A reversible change of contact resistance with applied contact voltage—the resistance decreasing with an increase of voltage—was found to be due entirely to the heating of the contacts arising from the passage of current. This was shown by comparing contact behavior at known temperatures with that at known voltages and checking the theory of contact temperature arising from the heating effect of current. This theory based on earlier work of Kohlrausch had been

[4] F. S. Goucher, *Phys. Rev.*, 35: 1429, 1930; 36: 375, 1930.

worked out previously in these laboratories by F. Gray[5] and independently by R. Holm.[6] The theory gives as an approximate formula

$$T = \text{const.} \frac{V^2}{K_0/\sigma_0} \qquad (3)$$

where T is the increase of temperature above room temperature, V the contact voltage and $(K_0/\sigma_0)$ the ratio of the thermal to electrical conductivity of the contact material. A reasonable value of $(K_0/\sigma_0)$ for carbon is obtained from these experiments. The conduction process is thus shown to be that which occurs in solid carbon, and no other effect, such as electronic discharge across small gaps, can be an important factor. This result is therefore in line with recent experiments of Holm[7] which have demonstrated the metallic nature of contacts between metals, and of carbon for relatively large contact forces.

The following experimental results have a direct bearing on the mechanism of change of resistance with change of contact force. Reversible resistance changes accompanying changes of contact force between fixed limits are obtained with these contacts, the resistance decreasing with increase of force. Also, the temperature coefficient of resistance is found to be substantially constant as the resistance is varied over a wide range in such a reversible cycle. Both these facts point to area change as the cause of the change of resistance with force, since we know that the elastic deformation of a contact would produce a change in contact area of the required type, and also since we might expect a measurable change in the temperature coefficient of resistance if the state of strain within the contact region were markedly altered. Although the mean stress within the contact area alters somewhat with the contact force, even when the area changes in accordance with elastic theory, this effect is relatively small.

These conclusions concerning the nature of the contacts and the mechanism of resistance change with contact force are in line with the assumptions underlying Gray's equation. Accordingly a study was made of the slopes of the reversible resistance force cycles for both single contacts and aggregates.

The technique used for the study of aggregates was similar to that employed for the single contacts with the exception that the lower contact $C_1$ consisted of a shallow cup with a conducting bottom and containing a large number of loosely packed granules several layers deep. The upper contact was made by cementing a large number of granules to the bottom of a conducting plate, the cement being such as to give a low resistance contact.

The experiments showed that for any reversible cycle the relation between the resistance and force was of the form

$$R = K(F)^{-n} \qquad (4)$$

in the case of both single contacts and aggregates. The exponent n varies somewhat from cycle to cycle when the force limits are the same and its average value depends on the force limits.

The largest values of n were obtained with the aggregates under such conditions of force limits as to indicate that the elastic straining of the aggregate during the cycle was relatively large. A maximum mean value substantially independent of the force limits over a wide range closely approaches 7/9, which is the maximum value consistent with equation (2). This indicates that with sufficiently large strains the aggregate may be made to act as though it were a single contact between spheres having rough surfaces obeying the laws assumed in the derivation of equation (2). On the other hand, for relatively small strains the value of n diminishes to values smaller than the theoretical minimum 1/3 consistent with equation (2). The measured values of n for single contacts are in general less than 1/3 and may become very small if the contact forces are large. These departures from theory appear to be associated with internal contact forces or cohesion which render the contacts relatively insensitive to changes in the applied forces. The existence of cohesion was readily demonstrated by the fact that the contacts always required a finite force to break them even when no current had passed through the contact.

All the experimental results are therefore consistent with the theory of area change due to the elastic deformation of the contact material. Furthermore, the realization of the theoretical maximum value of n in the case of the highly strained aggregates indicates that in a granular mass deformed elastically not only do the contact areas change in the case of those contacts already established, but that new contacts possibly between other granules may be made and broken in a reversible cycle.

[5] Unpublished.
[6] *Z. tch. Phys.*, 3: 290–294, 320–326, 349–357, 1922.
[7] *Wiss. Ver. a. d. Sieman's-Konzern*, 7: 217–271, 1929.

# OBITUARY

## MEMORIAL TO JAMES MELVILLE GILLISS

THE Secretary of the Navy has forwarded to the Ambassador at Santiago, Chile, a bronze bust of the late Lieutenant James Melville Gilliss, U. S. Navy. Mrs. Louise Kidder Sparrow, of Hyannis, Massachusetts, was the sculptress. Congress on June 9, 1930, passed an act providing an appropriation to procure for presentation to the Chilean National Observatory,

through the Secretary of the Navy, in the name of the United States Naval Observatory, a bronze bust of the late Lieutenant Gilliss, whose memory is honored by officials of Chile.

According to information sent from the Navy Department, Lieutenant Gilliss was the first to conduct a working observatory in the United States and to give his whole time to practical astronomical work. He published the first volume of observations and prepared the first catalogue of stars and planets compiled in the United States.

Lieutenant Gilliss was born in Georgetown, District of Columbia, September 6, 1811. He entered the United States Navy as a midshipman at the age of fifteen and served on the U. S. S. *Delaware,* ship-of-the-line, the *Concord* and the *Java* until 1831, when he was promoted to the rank of passed midshipman. He spent a year at the University of Virginia and later studied in Paris. In 1837, he succeeded Lieutenant Charles Wilkes, who was organizing his expedition to the Antarctic, in charge of the Depot of Charts and Instruments then located in Washington, D. C., on a site about 1,000 feet north of the Capitol.

In 1842, a bill was passed by Congress authorizing the establishment of an astronomical observatory and Gilliss prepared the plans for the building and arranged for the instruments. The site of the new building, the Naval Observatory, was on Braddock Hill, where the Washington, D. C., Naval Hospital is now located, 23d and 25th Streets between E Street and Potomac Park, N. W.

Gilliss's connection with astronomical observations, covering the period from 1838 to 1842, brought him in contact with Dr. Gerling, of Marburg University. Dr. Gerling proposed a new method of deducting the solar parallax from observations of Venus taken from points as far apart as possible in opposite hemispheres, but nearly on the same meridian.

These requisite physical conditions suggested to Gilliss that the obvious place for the other observatory was in Chile. His efforts finally brought authorization for funds from Congress, the project awakening world-wide interest, and he was assisted in his plans and assembling of equipment by some of the most prominent scientists of the day.

Upon the completion of the new observatory in Washington, Gilliss was assigned to duty on the Coast Survey in reducing for its use the entire series of moon-culminations previously observed and published by him. From November, 1848, to 1852, he was engaged in making observations for the determination of the solar parallax.

In August of 1849 he sailed for Valparaiso at the head of a scientific expedition. He located at Santiago, Chile, where he found atmospheric conditions, the necessary physical comforts and availability of repair facilities ideal. The Chilean Government rendered every assistance to Lieutenant Gilliss. There he completed a series of observations of great value. He likewise accumulated a vast amount of information concerning earthquakes and other subjects.

When Gillliss's work was finished, the interest he had awakened in astronomy did not flag. Chileans desired to found a National Observatory. The observatory which Gilliss had established was turned over to Chile as the Chilean National, hence the Chileans' affectionate reference to Gilliss as "the father of astronomy in Chile."

He visited Peru in 1858 to observe the total eclipse of the sun and in 1860 observed a total eclipse of the sun in the Washington Territory. In 1861, he was assigned to take charge of the Washington Naval Observatory. He died in Washington, D. C., in February, 1865.

## RECENT DEATHS

DR. ELLWOOD HENDRICK, curator of the Chandler Chemical Museum of Columbia University and author of many books popularizing chemistry, died on October 30, at the age of sixty-eight years.

DR. HORACE E. STOCKBRIDGE, formerly director of the Indiana Experiment Station and from 1890 to 1894 president of the North Dakota Agricultural College, died on October 30, aged seventy-three years.

DR. PRESTON M. HICKEY, head of the department of roentgenology of the University of Michigan, died on October 30. He was sixty-four years old.

THE death at the age of eighty years is announced of George McLane Wood, for twenty-five years editor of the United States Geological Survey in Washington. He had served with the survey from 1886 to 1925.

ACCORDING to a press dispatch Max von Pidoll and his wife committed suicide simultaneously, but in different localities, on October 29. Dr. von Pidoll, who had recently been appointed professor of mathematics in the University of Innsbruck, had suffered from a chronic illness. He was forty-three years old.

*Nature* reports the death of Dr. D. Adamson, past president of the Institution of Mechanical Engineers, on October 11, aged sixty-one years; of Dr. H. R. H. Hall, keeper of the Egyptian and Assyrian Antiquities, British Museum, on October 13, aged fifty-seven years; of Professor Paul Wagner, director of the Agricultural Research Station at Darmstadt from

1872 until 1923, on August 26, aged eighty-seven years, and of Dr. C. Powell White, for some years director of the Helen Swindells Cancer Research Laboratory at the University of Manchester, pathologist at the Christie Hospital, Manchester, and a member of the executive committee of the British Empire Cancer Campaign, on September 26, aged sixty-three years.

# SCIENTIFIC EVENTS

## THE AMERICAN ASSOCIATION'S GRANTS FOR RESEARCH

THE American Association for the Advancement of Science grants each year a number of awards to aid in research. The next allotment of these grants will occur during December, 1930. Applications should be addressed to Burton E. Livingston, permanent secretary, Smithsonian Institution Building, Washington, D. C., and should be in his hands not later than December 1.

There will be available for the next year a total of about $3,000. The amount of the individual grants is usually for sums of from $50 to $500. The grants are designed to assist research projects in which some financial assistance will make possible the carrying on of investigations that would otherwise be handicapped. They may be used, for example, for purchasing special apparatus or special facilities that are otherwise unavailable. Application blanks for these grants may be secured from the office of the permanent secretary, although it is not necessary that such special application blanks be used. It is, however, important that any application be supported by letters from qualified scientific men who are acquainted with the proposed research.

These applications are considered by a committee on grants for research, which consists of the following members:

Walter S. Adams, astronomy.
Charles P. Berkey, geology.
Arthur H. Compton, physics.
Karl F. Kellerman, botany.
W. Lash Miller, chemistry.
George H. Parker, zoology.
Oswald Veblen, mathematics.
William C. White, medicine.

Announcement regarding the awards of the grants will be made in January, and the funds can then be secured on demand. When a grant is awarded, it is expected that its recipient make a report within a year as to the progress of the research for which the grant is intended. A report of some kind should be submitted also when the studies are brought to a conclusion. Such a report should give detailed references to any publication that has been made on the grant project, and if reprints or copies of these publications are available they should be included. It is expected, also, that suitable acknowledgment be made for the financial aid given from such a grant when the results of the studies are published. This acknowledgment might take such a form as "Financial aid for the work here reproduced was received from the American Association for the Advancement of Science in the form of a grant for the year 1931."

ARTHUR H. COMPTON, *Chairman,*
*Committee on Grants for Research*

## HEALTH SURVEYS BY THE YALE SCHOOL OF MEDICINE

CONSTANTLY increasing interest in public health is being evidenced by Connecticut communities, according to a statement made by Dr. Ira V. Hiscock, professor of public health in the Yale School of Medicine. At the present time the department is conducting surveys in four cities and towns, Winsted, Stratford, West Hartford and Haddam. In each instance the study is being made at the request of the community and with the approval of the local health officer and of the state department of health.

Similar surveys, or "public health inventories" have already been made in Greenwich, North Haven, Westport, Middletown, Hartford, Ansonia, New Haven, Hamden, Manchester and Danbury. The printed report of the Danbury survey has just come off the press.

By the terms of the endowment the department of public health at the Yale School of Medicine is charged with the obligation to promote the general cause of public health in the state of Connecticut. Its expert services are therefore placed at the disposal of any community desiring to take stock of conditions pertaining to the health of its members and to inaugurate such measures as may be needed to improve them. Although these services are given without charge, the department makes certain requirements in order to be sure that its efforts will bear fruit. The community must guarantee the full cooperation of all its agencies; a permanent committee must be formed to assist in an advisory capacity in making the survey and to see that the recommendations resulting from the study are carried into effect in so far as possible. The community must also pay the

traveling expenses of the staff and the cost of printing the report.

This work was commenced in 1917, and during the past four years has become so extensive that the staff of the department of public health devotes a considerable amount of its time to it. Selected graduate students also assist in the field work. In general, the department feels a responsibility toward the health programs of the state similar to that which the clinical departments of the School of Medicine bear toward the wards and dispensary of the New Haven Hospital. Full cooperation of state health agencies, including the department of health, dairy and food commissioner, commissioner of domestic animals, water commissioner and department of education is always obtained.

In addition to these health survey activities in Connecticut, Dr. C.-E. A. Winslow, head of the department, and Professor Hiscock have been called upon individually to conduct or assist in conducting health surveys in many communities outside the state, among them Boston, Worcester, New Bedford, Minneapolis; Cattaraugus County, New York, Los Angeles County, Santa Barbara County, California, San Francisco, Honolulu and Kansas City. The department has been called upon to make so many surveys in Connecticut that appointments are now made a year in advance.

## ENLARGEMENT OF THE HARVARD PHYSICAL LABORATORIES

HARVARD'S new research laboratory of physics, now under construction, which is to connect the present Jefferson and Cruft physical laboratories, should be completed by the middle of February, according to Dr. F. H. Crawford, instructor and tutor in the division of physical sciences, in a statement for the Boston *Transcript*.

The research laboratory will be approximately two-thirds the size of the Jefferson laboratory and will be devoted entirely to research. In conjunction with its erection, the interior of Jefferson laboratory will be completely remodeled affording much greater laboratory space for students than is now available. The new building has been made possible by an endowment fund raised during the last two years by alumni and many others interested in the physical sciences.

In the basement of the new laboratory will be rooms for high-pressure experimentation, for x-ray apparatus, and for research in high frequency and vacuum tubes. Beneath this will be a sub-basement where there will be a special x-ray work-room sheathed in lead to prevent the filtration of the rays into photographic appliances or other apparatus that they would harmfully affect. The basement is to be equipped with double walls which will prevent outside disturbances from affecting the extremely delicate measurements essential to research. Rooms will be soundproof and of constant temperature. A huge one hundred thousand volt storage battery, one of the largest of its kind in the world, will also be situated underground.

The second floor will be devoted to offices, conference rooms and a section for high frequency and radio research work. The latter is placed near the Cruft laboratory end. According to the contractor's specifications, the new building will have a volume of about five hundred thousand cubic feet and the walls of the library, lecture room and corridors will be coated with a special sound-absorbing plaster.

All motors will be mounted so as to counteract vibration. Another precaution against unnecessary noise is that special blocks of wood will be set in the wall to facilitate the attachment of machines at any time. There will be special electrical connections between all the rooms so that any voltage may be obtained throughout the building. All machines in the laboratory will have their own motors obviating the necessity of setting in motion a large system of generators and pulleys.

The third floor will house a physics library done in oak panelling which will be adjacent to a large conference room. The top floor will be given over to offices, small research rooms and a department devoted to computing equipment.

## THE SEMI-CENTENNIAL OF THE NEW JERSEY STATE EXPERIMENT STATION

THE completion of fifty years of service to agriculture by the New Jersey State Agricultural Experiment Station was celebrated at New Brunswick on October 8 and 9. The exercises included a large outdoor meeting under the auspices of the station, at which the principal speaker was Dr. A. F. Woods, director of scientific work of the U. S. Department of Agriculture, and a convocation by Rutgers University addressed by Sir John Russell, director of the Rothamsted Experimental Station, and followed by the conferring of the honorary degree of doctor of science upon six scientific men of international reputation.

These were Dr. L. O. Howard, long chief of the Bureau of Entomology; Dr. C. F. Marbut, chief of the Soil Survey Division; Dr. Theobald Smith, director of the department of animal pathology of the Rockefeller Institute for Medical Research; Sir John Russell, Dr. S. Orla-Jensen, of Denmark, an authority in dairy bacteriology, and Dr. L. B. Mendel, of Yale University, known for his studies in food and nutrition.

H. L. Knight, editor of the *Experiment Station Record*, states that the New Jersey station is one of

the pioneer experiment stations in this country. It was organized by act of the state legislature in 1880, thus antedating the Hatch Act by 7 years, and is still maintained without direct federal aid, though associated closely with the New Jersey College Experiment Station under a common directorship since 1895. Its establishment and early development were due largely to the efforts of Dr. George H. Cook, professor of chemistry and natural science in Rutgers, who was its director until his death in 1889. Its subsequent growth and progress have been profoundly influenced by Dr. E. B. Voorhees, its director from 1893 to 1911, and Dr. J. G. Lipman, director since 1911. A feature of the celebration was the unveiling of a memorial tablet commemorating the services of Dr. Cook and Dr. Voorhees.

# SCIENTIFIC NOTES AND NEWS

ACCORDING to an Associated Press dispatch from Stockholm the Nobel Prize in medicine has been awarded to Dr. Karl Landsteiner, formerly of the University of Vienna and since 1922 a member of the Rockefeller Institute for Medical Research in pathology and bacteriology.

DR. OTTO FOLIN, professor of biochemistry at Harvard University, has been named as the first recipient of the Scheele Medal, awarded him by the Chemical Society of Stockholm. Award of the medal was announced in connection with the dedication of the Institute for Biochemistry building in Stockholm.

THE Perkin Medal for 1931 has been awarded to Arthur D. Little. This medal is awarded on a basis of a lifetime of achievement by a committee composed of representatives of five leading chemical societies. The presentation will be made at a joint meeting of the societies to be held on January 9, probably at the Chemists' Club, New York.

DR. HUGH S. CUMMING, surgeon-general of the United States Public Health Service, was installed on October 31 as president of the American Public Health Association, succeeding Dr. A. J. Chesley, of St. Paul, Minnesota. Dr. William C. Hassler, health officer of San Francisco, was named president-elect to take office when Dr. Cumming has completed his term in 1931. Other officers named who will assume office next year are Dr. Rafel Silva, of Mexico, first vice-president; Dr. J. W. S. McCullough, of Toronto, second vice-president; Dr. A. H. Flickwir, of Fort Worth, third vice-president; Dr. Louis I. Dublin, of New York, treasurer, and Dr. W. S. Rankin, of Charlotte, North Carolina, chairman of the executive board. Mr. Homer N. Calver, of New York, was reappointed executive secretary.

AT the forty-first annual meeting in Denver, October 14–16, of the Association of American Medical Colleges, the following officers were elected: *President,* Dr. Maurice H. Rees, Denver; *Vice-president,* Dr. Charles C. Bass, New Orleans, and *Secretary-treasurer,* Dr. Fred C. Zapffe, 25 East Washington Street, Chicago (reelected). The next annual meeting will be held in New Orleans in 1931.

DR. CARLETON R. BALL, formerly principal agronomist in charge, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and now engaged in agricultural writing, was elected president of Gamma Sigma Delta, Honorary Society of Agriculture, at its annual meeting on October 14.

CARLOS E. CHARDON, commissioner of agriculture of Porto Rico, has been elected chancellor of the University of Porto Rico, succeeding Dr. Thomas E. Benner, who is now at Teachers College, Columbia University. Commissioner Chardon, who is thirty-three years old, is a graduate of Cornell University and is the first Porto Rican chosen to head the university.

DR. A. L. STRAND, of the University of Minnesota, has accepted the appointment as head of the department of entomology at the Montana State College, Bozeman, succeeding Professor R. A. Cooley, who will devote himself to research work. The appointment carries with it the positions of entomologist of the experiment station, state entomologist and secretary of the State Board of Entomology.

DR. RALPH W. CHANEY, of the Carnegie Institution of Washington, who has been carrying on teaching in the department of paleontology at the University of California during the past semester in conjunction with his work for the institution, has been appointed lecturer at the university. He is instructing some of the classes which were given by Professor W. D. Matthew, chairman of the department, whose death occurred on September 24.

RAYMOND H. ROGERS, class of 1925, New York State College of Forestry, in charge of the Iroquois Forest of F. Ambrose Clarke, Cooperstown, New York, has been awarded a forestry fellowship by the Charles Lathrop Pack Forest Education Board.

DR. H. T. HILLSTROM, of the University of Minnesota, has been appointed head of the department of roentgenology and radio-therapy at Vanderbilt University.

*Nature* reports that the council of the University of Manchester has accepted with regret the resignation of Professor O. T. Jones, who has held the chair of geology and the directorship of the Geological Laboratories since 1919. Professor Jones has been elected to the Woodwardian chair of geology in the University of Cambridge, and will vacate his Manchester appointment in December. The council has also accepted the resignations of Dr. John Walton, senior lecturer in botany, who has been elected to the Regius chair of botany in the University of Glasgow, and of Mr. L. J. F. Brimble, lecturer in botany.

DR. J. E. ACKERT, professor of zoology, experiment station parasitologist and chairman of the graduate council in the Kansas State Agricultural College, is spending the year 1930–31 abroad. He participated in the fourth World's Poultry Congress in London in July, and the eleventh International Zoological Congress in Padua in September. Dr. Ackert will be at the Molteno Institute of Parasitology, University of Cambridge, England, during the rest of the year.

PROFESSOR A. ELIZABETH ADAMS, of the department of zoology at Mount Holyoke College, is carrying on investigations in the department of animal genetics at the University of Edinburgh, Scotland.

J. E. CHAPMAN, assistant professor of agronomy of the North Dakota Agricultural College, has returned from Cornell University where he spent his sabbatical leave in study for an advanced degree.

DR. A. H. GEE, assistant professor of bacteriology at the Scripps Institution of Oceanography, the University of California, has returned from a summer spent at the Laboratory of the Carnegie Institution at Tortugas, where he made a collection of representative corals which has been added to the series of collections of the Scripps Institution.

DR. AND MRS. WILLIAM M. MANN left Washington on October 24 for New York City where they embarked for points in Panama and Honduras. The trip is primarily a vacation, but it is anticipated that Dr. Mann will obtain both plants and animals that will be needed for stocking the Reptile House of the National Zoological Park, which should be in condition to receive them upon his return early in December.

DR. ANSON HAYES, director of metallurgical research with the American Rolling Mills Company, was the guest of honor and speaker at a dinner of Sigma Xi at Iowa State College on October 23. He addressed the society on "Industrial Research and Some of the Tools it Uses."

DR. WILLIAM MCPHERSON, president of the American Chemical Society, is making a lecture tour of twenty-two local sections of the society. He is addressing sections in Kentucky, Indiana, Illinois, Missouri, Kansas, Oklahoma, Texas, Louisiana, Alabama, Florida, Georgia, Tennessee, North Carolina, Virginia and West Virginia. The titles of his lectures are (1) "Methods of Nature"; (2) "Reminiscences of Great Teachers of Chemistry," and (3) "Chemistry of Organic Compounds of Titanium." His tour began on October 27 and ends on December 5. These lectures were arranged by the local section officers committee, of which Dr. Ellice McDonald is secretary.

THE second Henry Herbert Wills Memorial Lecture in physics, founded to commemorate the gift of the laboratory to the University of Bristol, was given by Professor J. Franck, of the University of Göttingen, on October 25, in the Henry Herbert Wills Physical Laboratory. The title of the lecture was "Relations between Spectroscopy and Chemistry."

CLARENCE H. MACKAY, president of the Postal Telegraph Cable Company, dedicated and laid the cornerstone of the new Mackay Science School building at the University of Nevada on October 24 for which Mr. Mackay gave the university $415,000, bringing the total gifts to the university of the Mackay family to more than one and a half million dollars. Judge George S. Brown, president of the Board of Regents, accepted the gift.

IN accordance with an agreement made by the Boards of Trustees of Ohio Wesleyan University and Ohio State University, students registered in the latter institution may carry on research work in astronomy and astrophysics at the Perkins Observatory of Ohio Wesleyan University under the supervision of its director. Graduate work may be arranged on the terms of the agreement which will lead to the degree of doctor of philosophy in astronomy and astrophysics, the degree to be granted by the Ohio State University, and the work to be published in the *Contributions* of the Perkins Observatory.

DR. RICHARD T. FISHER, director of the Harvard Forest, announces that an endowment fund of $200,000 has been created for research work in the forest. The endowment will be known as the Charles Lathrop Pack Forestry Fund. Mr. Pack gave $100,000 on condition that the same amount should be raised from other sources; that provision has now been fulfilled. The Harvard Forest is at Petersham, Massachusetts, where about 2,000 acres of valuable timberland were acquired in 1907 through the generosity of John S. Ames, '01. Several neighboring tracts have since been added.

THE *American Journal of Cancer*, the first number of which will appear on January 1, is a direct continuation of *The Journal of Cancer Research* which originated with the American Association for Cancer Research. The publication of the new journal has been rendered possible by the generosity of Mr. Garvan and Mr. Buffum, of the Chemical Foundation. The next number will be Volume xv, thus directly continuing *The Journal of Cancer Research*. With the ample funds which have been provided, it will be possible not only to print the research articles which have been appearing in *The Journal of Cancer Research*, but also to include clinical, statistical and educational aspects of cancer, together with abstracts of the most important articles on cancer. Dr. Francis Carter Wood will be the editor, and the journal will be published at Crocker Institute of Cancer Research, 1145 Amsterdam Avenue, New York.

BEGINNING January, 1931, the American Society of Clinical Pathologists will publish a bi-monthly journal known as the *American Journal of Clinical Pathology*. This journal will publish original papers dealing with all phases of clinical pathology and closely related subjects. The editors will also make an effort to publish articles dealing with new methods and comparisons of old methods in the application of clinical pathology to medicine and surgery. Manuscripts should be sent to Dr. T. B. Magath, editor, Mayo Clinic, Rochester, Minnesota. The advisory editorial board consists of Drs. J. A. Kolmer, A. H. Sanford, B. C. Crowell, R. A. Keilty, F. W. Hartman, Herbert Fox, K. M. Lynch, S. P. Reimann, W. S. Thomas, C. S. Butler, R. A. Kilduffe and H. J. Corper.

THE appointment of Dr. W. B. White, chief of the food control laboratory, Food and Drug Administration, U. S. Department of Agriculture, as a member of the Food Standards Committee, was approved on October 14 by Secretary of Agriculture Arthur M. Hyde. This appointment fills the vacancy created by the death of Dr. R. W. Balcom, former chief of the food control laboratory. The Food Standards Committee consists of nine members, three representing the U. S. Department of Agriculture, three the Association of Dairy, Food and Drug Officials of the United States and three the Association of Official Agricultural Chemists. The committee acts in an advisory capacity to the Secretary of Agriculture and to the Food and Drug Administration. Its personnel, in addition to Dr. White, is as follows: W. C. Geagley, state analyst, Department of Agriculture, Lansing, Michigan; E. L. Redfern, chief chemist, Department of Agriculture, Des Moines, Iowa; Guy Frary, state chemist, Vermilion, South Dakota; I. L. Miller, state food and drug commissioner, Indianapolis, Indiana; Dr. E. M. Bailey, chemist, Agricultural Experiment Station, New Haven, Connecticut; Charles D. Howard, chief, Division of Inspection, State Board of Health, Concord, New Hampshire; W. S. Frisbie, Food and Drug Administration, U. S. Department of Agriculture, chairman, and A. S. Mitchell, Food and Drug Administration, secretary.

A PLAN for the formation of a research foundation was under consideration by the American Congress of Physical Therapy, recently in session in St. Louis. The proposal for the foundation was offered by Dr. John S. Hibben, of Pasadena, California. The plan suggests the organization of a research council on physical therapy under the direction of the congress. Several St. Louis philanthropists have expressed a willingness to finance a research program over a five-year period. Approximately 1,000 physicians and surgeons attended the congress.

THE Institute of Medicine of Chicago has received from an anonymous source $10,000 which will be known as the Joseph Almarin Capps Endowment Fund.

CORNELL UNIVERSITY has received another anonymous gift from the anonymous donor who last year sent a cashier's check for $20,000 and requested that no effort be made to discover his identity. This time the check was for $10,000, to be used for the engineering college.

EIGHT fellowships for the training of leaders in forestry have been awarded for the year 1930–31 by the Charles Lathrop Pack Forest Education Board, and the board is preparing to receive applications for fellowships for the year 1931–32. The fellowships already granted cover a wide range of practical and theoretical forestry, including reforestation, management of private forest estates, cooperative marketing of forest products, silvicultural management and forest pathology. Six to eight fellowships, with stipends ranging from $500 to $2,500, are available for the coming year. Their purpose is to encourage men who have shown unusual intellectual and personal qualities to obtain training that will best equip them for responsible work, either in the general practice of forestry, in the forest industries, in the teaching of forestry, in forest research or in the development of public forest policy. Applications will be received not later than January 15, 1931. Application forms and detailed announcements can be obtained from Ward Shepard, Secretary of the Charles Lathrop Pack Forest Education Board, 1214 Sixteenth St., N.W., Washington, D. C.

THE Board of Estimate of New York City has accepted the offer of Mr. John D. Rockefeller, Jr., to

give the city the fifty-six-acre Billings estate on Washington Heights, to be used for park purposes, in return for the closing of East Sixty-fourth and East Sixty-eighth Streets, between York Avenue and Exterior Street, for the respective purposes of expanding the Rockefeller Institute and the erection of the New York Hospital. The city will receive land with an assessed valuation of $2,000,000 and in return will give up land with an assessed value of only $300,000. It is estimated that additional work will cost Mr. Rockefeller about $2,065,000, against the city's $700,000.

FINAL proceedings in the acceptance of land tendered the United States Government by the governors of North Carolina and Tennessee to constitute the Great Smoky Mountain National Park have been completed, according to an announcement of the Interior Department. Titles to the land have been formally passed on by the attorney-general and the government has announced its acceptance. The tract given by the two states covers an area of 158,876 acres and will form a nucleus for a park with a minimum area of 427,000 acres. Under the act of Congress authorizing its establishment, the park may be extended to include over 700,000 acres. The Great Smoky Mountain National Park will have roads and trails, being planned like the western parks, and will be divided equally between North Carolina and Tennessee. A great mountain range will carry the border between the states. The act under which the park was established provided for donations of land in order to reach the full status. Other eastern parks which have been authorized by the Congress and which are awaiting receipt of land are the Shenandoah National Park in Virginia and the Mammoth Cave project in Kentucky.

A START on the elimination of private lands in Glacier National Park has been made with the acceptance by the Department of the Interior of deeds to approximately 140 acres of land at the foot of Lake McDonald, not far from park headquarters. Altogether about sixty per cent. of the land in this area has been acquired or is in process of acquisition. These acquisitions will simplify park administration and will also make possible the remedying of unsightly conditions that have prevailed around the foot of the lake. An allotment of $198,000 of government funds was used in arranging for the consummated and pending acquisitions.

SIR J. J. THOMSON, as president of the Association of Special Libraries and Information Bureaus, writes to the London *Times* to draw attention to the formation by the association of a panel of expert translators. He says that those who require the services of a translator often experience difficulty in finding one who has both a knowledge of the language and also of the special subject concerned, and the difficulty increases where the language is uncommon and the subject highly technical. Proficiency in the language is not enough. To afford specialized service the translator must have not only a good knowledge of the language, but a really close acquaintance with the subject he has to translate—*e.g.*, the law, metallurgy, medicine, architecture, management, or whatever the subject may be. With the object of overcoming this difficulty, which has been brought to their notice continually, the council of the association recently appointed a committee consisting of Dr. S. C. Bradford, librarian, the Science Library; Allan Gomme, librarian, the Patent Office; Dr. R. S. Hutton, director, British Non-Ferrous Metals Research Association; Miss A. L. Lawrence, Intelligence Officer, British Medical Association; Brigadier-General Magnus Mowat, secretary, Institution of Mechanical Engineers; E. I. Robson, librarian, Institute of Agricultural Engineering, to prepare a scheme for establishing a panel of translators having both linguistic and technical qualifications, the part taken by the association being to act as a connecting link between the translator and the user. Names of approved qualified persons are now being registered.

# DISCUSSION

## DISCONTINUANCE OF THE LA JOLLA PEROMYSCUS PROGRAM

THE studies of geographic variation and heredity in mice of the genus *Peromyscus*, which have been conducted by the writer and his assistants at La Jolla for more than sixteen years, have recently been discontinued. These studies were commenced early in 1914, under the auspices of the Scripps Institution for Biological Research of the University of California. Owing to a radical change of program and of policy, some eight or nine years later, in accordance with which the Scripps Institution for Biological Research was finally transformed into the Scripps Institution of Oceanography, the continuance of such studies at the La Jolla station became anomalous. It was inevitable that the *Peromyscus* program should either be transferred to some other establishment or be discontinued altogether.

Since these studies were (and I think still remain) the only serious attempt which had been made to analyze geographic variation, in either mammals or birds, by precise quantitative methods, and particularly to determine the genetic status of subspecific characters, it was thought by many that they ought

not to be terminated merely as an incident in a change of administrative policy. This view was concurred in by Dr. Vaughan, at the time of his succession to the directorship of the Scripps Institution, and the *Peromyscus* studies were continued for some years after the institution had adopted an otherwise exclusively oceanographic program. But such an anomalous situation could not be expected to continue indefinitely. As an emergency measure, the Carnegie Institution of Washington came to the rescue in 1927, in order that results already obtained or material already at hand might be utilized to the fullest. The liberal contribution then made by the Carnegie Institution permitted not only of full utilization of previous data and material, but made possible considerable further progress with the work. The funds which were contributed for the purpose, however, are now exhausted.

Despite past and recent efforts by the administration of the University of California, it has proved to be impracticable to transfer this program of research to Berkeley, and to have it conducted under the auspices of any university department there. Such a time-consuming research program is naturally incompatible with one's carrying an even moderate teaching schedule, particularly if one's teaching experience has been limited.

For these reasons, the *Peromyscus* program, at least so far as the present writer is concerned, has been brought to a close. In its place, studies will be undertaken of the ecology and possibly the genetics of certain species of fishes, both fresh water and marine. Certain of these studies are already in progress. The remaining stock of *Peromyscus*, comprising seven subspecies, has been sent to Dr. Lee R. Dice, of the Zoological Museum, University of Michigan.

That university is the only one, so far as I know, in which experimental breeding operations are being conducted in connection with its museum of zoology. It is to be expected that other universities will, in time, recognize the wisdom of such a policy.

It has seemed desirable to issue the foregoing statement, owing to misunderstandings which have prevailed for some years regarding the status of the investigations in question and the writer's connection with the Scripps Institution. I will conclude by saying that reprints of papers, including those on genetic subjects, will still be welcomed by the writer at the same address.

F. B. SUMNER

SCRIPPS INSTITUTION OF OCEANOGRAPHY

## PHYSICOCHEMICAL PHENOMENA IN THE ANTARCTIC

THE paper of Rear Admiral Richard E. Byrd entitled "The Conquest of Antarctica by Air" published in the August number of the *National Geographic Magazine* brings out several facts which are not only of general scientific interest but are also of particular importance to those who have to deal with low temperature conditions, *e.g.*, aviation and pilot balloon investigations.

The influence of intense cold on chemical reaction appeared when he was examining a crevasse while the temperature was *only* 50 degrees below zero (presumably F.). Byrd writes: "We could not use hand flashlights, because the cold stopped the chemical action of the dry batteries. We provided light by linking a portable gasoline engine generator to a locomotive-type searchlight pointed down the dark fissure." When the thermometer was 71 degrees below, they had to warm the candles used under the meteorological balloons before they could be lighted.

The ready formation of finely dispersed (presumably colloidal) ice is shown by the following: "It was amazing to see fogs at these temperatures. The air holds a very small amount of moisture at 50 below, but when the wind stirs the warmer and the colder air condensation of this minute amount of moisture occurs and a real fog is evolved. . . . Even a book lying against a cold wall steamed like a teakettle when opened in a slightly warmer atmosphere. When a man stood inside the entrance to one of the house tunnels, the vapor formed by his breathing was so heavy the house appeared to be on fire." Water in the form of colloidal ice seems to be the cause of so great an effect from so small a quantity.

Some peculiar physical effects may be noted. At 64 below, "It was so cold that when a man stood outside the tunnel he could hear his breath freeze. The condensation caused a faint swishing sound like snow blown across the ice surface by a strong wind." Kerosene froze solid. "One mid-July day the mercury touched 71 below zero. That caused the barrier snow to contract sharply. All about us we could hear the ice snapping and cracking. Then, as large cracks occurred, the bay ice began booming like distant guns. The guy wires on the antenna posts became as taut as harp strings and the wind played odd humming tunes on them."

In order to avoid dangers following failure of soldered cans, which Dr. B. T. Brooks pointed out as due to formation of gray tin ("tin disease") at low temperatures, the supplies (oil, gasoline, etc.) were packed in copper cans made with silver solder.

JEROME ALEXANDER

## CIRCULAR SHADOWS FROM VORTICES

YESTERDAY while I was sitting in the bright sunshine on a rock in the middle of the Croton River my

attention was called to circular shadows on the rocks and the bottom of the stream. These shadows varied in size from about one inch to one and one half inches in diameter. Around the outer edge of the shadows was a halo and occasionally faint rotating streamers.

The water was quite clear and it was perfectly obvious that floating objects were not responsible for the shadows. It was observed that the shadows came from vortices and, further, that these vortices depressed the surface in such a manner that the light, falling in the vortex, was deflected outward somewhat, as in the concave lens.

This is simply one of those interesting phenomena which I never happened to observe previously. I am thinking that perhaps others who read this may find one additional thing to look for when they are in the open.

F. C. BROWN

MUSEUMS OF THE PEACEFUL ARTS
NEW YORK, N. Y.

## PLANETARY SYSTEMS

IN his retort to Professor Porter, who had criticized him for saying that planets like those of the solar system are rare, though there are millions of stars more or less similar to our sun, Professor Arthur H. Compton seems to feel that he fully justifies his position by citing as his authority the distinguished theoretical astronomer, Sir J. H. Jeans.

Doubtless Professor Porter overstates his case in claiming that "there is absolutely no reason for the assumption that the formation of attendant worlds may not be the ordinary course of evolution for the single stars." On the other hand, it must be recognized that Jeans's conclusion is based upon highly theoretical assumptions and should not be given too much weight. It is to be feared that Professor Compton has erred in asking his readers to accept as a demonstrated fact what is in actuality little more than an educated guess.

G. B. BLAIR

UNIVERSITY OF NEVADA

# SCIENTIFIC BOOKS

*The Size of the Universe: Attempts at a Determination of the Curvature Radius of Spacetime.* By DR. LUDWIK SILBERSTEIN. viii + 215 pp. Oxford University Press, London, 1930.

THE problem of the curvature of space was born directly out of the relativity theory of gravitation and was therefore first raised seriously by Einstein, who was led to adopt as a basic geometry of the universe one of constant curvature in space, leaving the time coordinate "straight." De Sitter, on the other hand, contemplated another possibility, in which the four-dimensional world is perfectly spherical, the time being curved along with the space coordinates. These two possibilities are generally referred to as Einstein's cylindrical world and de Sitter's spherical world, and they fairly exhaust the worlds of constant curvature.

Does our own world belong to the class of constant curvature, and, if so, is it of the cylindrical or the spherical class, and what is the actual value of its radius of curvature? These are the questions Dr. Silberstein sets out to answer.

The first part of the book is concerned with the general theory of curved surfaces, the theory of tensors and the relativity theory of gravitation. The second part is devoted to a discussion of the relative merits of Einstein's and de Sitter's worlds. The third part contains an extensive, and rather unexpected, criticism of Dr. Hubble's estimate of the world radius corresponding to Einstein's cylindrical world. The fourth and fifth parts are concerned with the Doppler effect in de Sitter's world and how this may be used to find the world radius from an analysis of the radial velocities of the stars. This latter problem is also the subject of miscellaneous notes at the end of the book.

The reader is likely to finish this book in a state of mingled admiration and depression. Its every page bears witness of a strong personality, and the formal style is unusually clear and attractive. The introductory chapter on non-Euclidean geometry is, in particular, a product of fine, artistic beauty. On the other hand, the book is written exclusively from Dr. Silberstein's personal point of view, and as this frequently runs opposite to the opinion of other authorities the reader will have to do a lot of reading in the general literature in order to be fully informed on the subject. For an astronomer it is especially disconcerting to read the last part and the notes. In fact, to search for the de Sitter-Doppler effect in the motion of the nearer stars seems, to put it mildly, like hunting for a needle in a haystack. Considering that in this search much more pronounced peculiarities in the laws of stellar motion have been sacrificed, Dr. Silberstein can scarcely blame the astronomers for having little faith in his results.

So much has been written about the curvature of space, both in scientific journals and in the press, that a separate book on the subject should meet with general approval. The present book seems more calculated to stimulate than to satisfy this demand. This may be fortunate, as, according to some recent

work of Abbé le Maître and of Eddington, the problem may be more complicated than was believed previously. In fact, the universe may, perhaps, not at all possess a constant world curvature; and it must be admitted that the preponderantly positive radial velocities of the spiral nebulae are most simply explained by assuming the whole universe to expand, and to have nothing to do with the de Sitter-Doppler effect.

On the whole, the subject of the curvature of space is one in steady progress, the present state of which does not encourage to any display of orthodox convictions, but which may become of considerably more cosmologic importance in the near future.

SVEIN ROSSELAND
OSLO UNIVERSITY OBSERVATORY

*Determination of Orbits of Comets and Asteroids.* By RUSSELL TRACY CRAWFORD. xi + 233 pp. McGraw-Hill Book Company, 1930.

A TEXT-BOOK designed for a college course of one semester to provide an introduction to the subject of orbit determination. The following subdivision of the book could be made: (*a*) Introductory chapters treating the motion of a body about the sun as attracting center, also including the subject of ephemeris computation; (*b*) Leuschner's method of orbit determination; (*c*) Merton's modification of the Gaussian method of orbit determination. Completely worked out examples and summaries of formulas for both methods and fourteen auxiliary tables are added.

As the author states in his preface, this work is different from other treatises on orbit computation. It is not intended to be complete, and does not, for instance, include the mathematical development of precession, nutation, special perturbations or least squares. "The definitive orbit" is very briefly treated, but logically, considering the fact that the book treats undisturbed orbits only.

Notwithstanding limitations set by the scope of the book, it is complete enough to be a very useful reference book. Those interested in more intricate problems, mainly of theoretical importance, which could not be fully treated, will find many helpful references to original publications.

This is the first time that a coherent presentation of Leuschner's method is published, after the original publication in Vol. VII of the Lick Observatory Publications. (Buchholz-Klinkerfues, 1912, gave little more than a set of formulas and examples.) Especially because many treatises on orbit computation entirely disregard the existence of other methods than the Gaussian we could have been satisfied with a book presenting Leuschner's method only. The fact that two methods, one representing the Laplacian and the other representing the Gaussian method, are given testifies to the broad attitude taken by Leuschner and his followers.

That Merton's development of the Gaussian method is chosen is not surprising. It has done away with a number of complications mainly due to the former necessity of adapting all formulas to logarithmic computation. The two methods offered are undoubtedly distinguished by theoretical clearness and adaptation to practical needs.

It would have been impossible within the scope of the book to include a critical comparison of methods of orbit computation. This is left to the student. The field which this book covers is very large, so that a selection was necessary. The author has made an admirable choice guided by his expert knowledge of the subject and experience in teaching it.

The book is beautifully printed; one can only wish that the subdivision of the chapters had been made more uniform and more distinct. The generous size of the pages (10 x 7 inches) has contributed much to its fine appearance, as many long formulas had to be included. The book is dedicated to Professor A. O. Leuschner, "a most stimulating teacher and inspiring director."

DIRK BROUWER
YALE UNIVERSITY OBSERVATORY

# SCIENTIFIC APPARATUS AND LABORATORY METHODS

## AN OBJECTIVE METHOD OF EVALUATING MUSICAL PERFORMANCE

IN the psychological laboratory of the University of Iowa we have developed instruments which enable us to record actual singing and playing accurately and quickly. This is done mainly with the strobophotograph camera designed by Professor Milton Metfessel[1] and recently improved by Tiffin and Reger. It virtually graphs two of the four elements of musical performance, namely, pitch and time. The other two elements, intensity and timbre, are not recorded.

A stroboscopic disk runs between the film and a neon lamp. The lamp flashes in frequency with the sound wave, and the film, moving past at a constant speed, registers a continuous picture of the stroboscopic effect. The stroboscope registers in terms of tenths of a tone but finer readings may be made in proportion to the steadiness of the tone.

The object of this note is to illustrate how this

[1] *Jr. Gen. Psychol.*, 2: 135–139, 1929.

method may be used in evaluating the singing or playing of an amateur as compared with a professional singer; or, for that matter, any comparison of two singers or players.

Figs. 1 and 2 are records in the scientific musical notation called the "pattern score" showing the rendition of "The Last Rose of Summer" by an amateur whom we shall call "Helen" and by Frances Alda, respectively. Assuming that Alda is a good representative of an artistic singer and that Helen is a promising amateur whose performance we wish to compare with a recognized artist, we may compare in detail the performance of the amateur with the performance of the recognized artist.

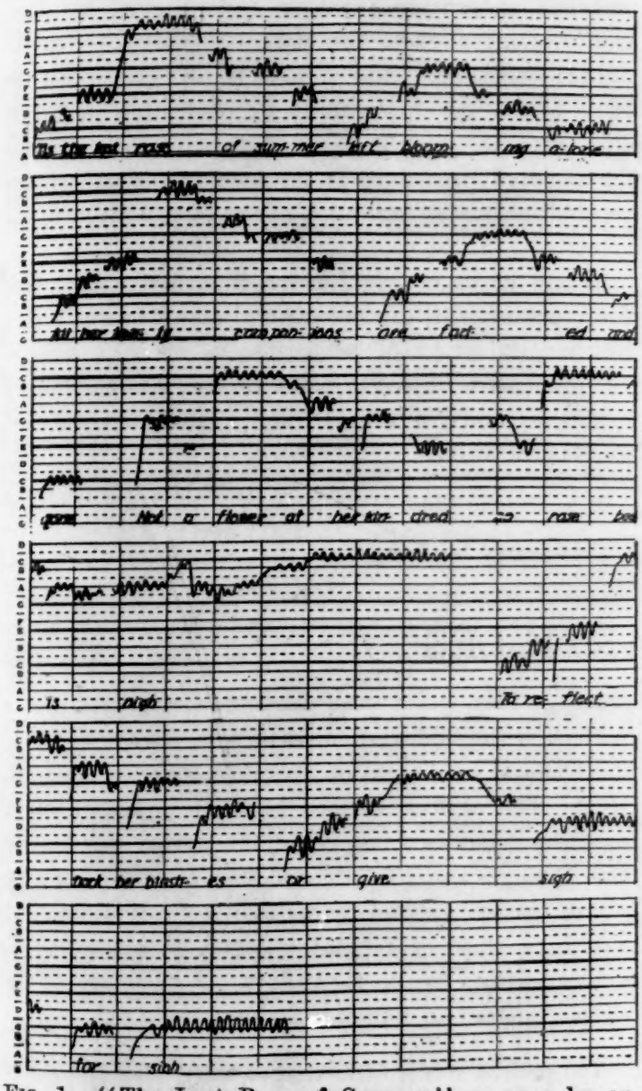

FIG. 1. "The Last Rose of Summer" as sung by an amateur "Helen."

Intonation is indicated in minute detail in the form of a graph for each note, showing in exact detail what was actually sung, as to pitch and time. The vertical lines divide the staff into seconds; the notes are indicated in the margin at the left; the solid lines indicate the white keys and the broken lines the black keys. The oscillations in the graph for each note show the character and extent of the vibrato.

One is struck with the great liberty that the artist takes with the conventional musical notes. Presumably the beauty in the rendition lies in the artistic deviation from the conventional notes, both as to pitch and time. It may be noted that these deviations from the true intonation are seldom heard in their true extent, even by the ear of good musicians, because we have the habit of apperceiving music in

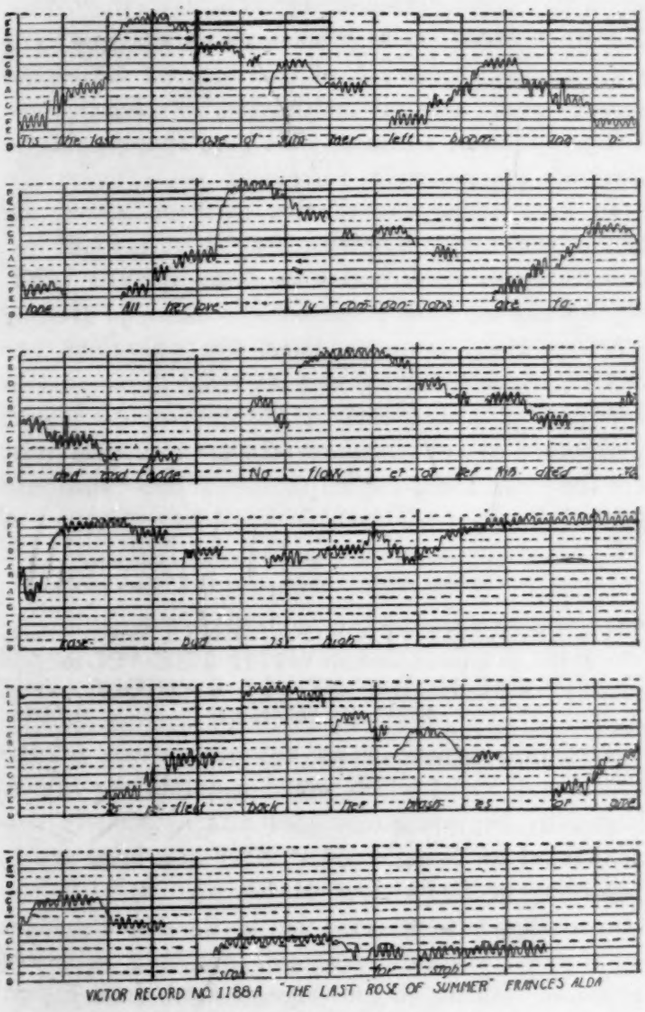


FIG. 2. "The Last Rose of Summer" as sung by Frances Alda.

terms of the conventional notation. At any rate one who is not familiar with the objective analysis of singing, such as here given, is surprised to find the artist deviating so greatly from the musical notation.

Now to evaluate our amateur singer we may at once make comparison of the relative duration and intonation of each tone throughout the selection, and the division of emphasis. We may then consider each note in detail: (1) as to the mode of attack; (2) as to the mode of release and transition; (3) as

to duration; (4) as to the mean pitch, the pitch actually heard tending to be approximately 6 per cent. of the extent of the vibrato below the center of the oscillation; (5) the vibrato, considering such facts as number of pulsations per second, the amplitude in pitch (each horizontal space representing a semitone), and regularity of the vibrato, and (6) the occurrence of mordents, as on the last syllable of "blooming" and the last syllable of "faded" by Alda. Numerous measures of subordinate elements for each of these factors may be made. Of special interest is the mode of glide, particularly within the tone itself, as on the words "the last" by Alda.

Here a single artist is taken as an example of a good singer. There are, of course, great differences among good artists; multiplying of illustrations brings out these features. We here simply wish to illustrate the principle.

In interpreting the relative performance of the two singers we must fall back upon a gradually accumulating series of norms which we are now building up for all these factors. For example, Helen's vibrato, which averages about five pulsations per second, is somewhat too slow as rated by our norms for artists. Alda's rate of about seven pulsations per second is approximately the most favored rate. On the other hand, the amplitude of Helen's vibrato is not quite as large as Alda's, or as the norms for artistic singers in general. This may or may not be in her favor. One of the writers is of the opinion that it is decidedly in her favor because the more subdued the vibrato the more pleasing it is to him.

But such subjective differences of opinion may now be gradually eliminated by two different processes: first, by measuring agreement in practice among the great artists; and second, by determining the best achievement of such artists under experimental control and submitting these to experimental analysis and evaluation from the point of view of experimental esthetics. This procedure of giving recognized artists the opportunity of perfecting performance with the aid of measuring instruments under fractionated procedure is the avenue through which we shall ultimately establish norms of artistic achievement.

When the other two factors, intensity and timbre, are recorded with the camera and added to our scientific musical score of performance, we shall have a comprehensive objective basis for the comparison of musicians and for the detailed quantitative account of musical value.

CARL E. SEASHORE,
JOSEPH TIFFIN

UNIVERSITY OF IOWA

# SPECIAL ARTICLES

## THE TREATMENT OF PATIENTS WITH ADDISON'S DISEASE WITH THE "CORTICAL HORMONE" OF SWINGLE AND PFIFFNER

THE preparation of an aqueous extract of the suprarenal cortex which would maintain the life of bilaterally suprarenalectomized cats indefinitely was announced by Swingle and Pfiffner in a brief article published in SCIENCE of March 21, 1930. Subsequently they have reported that by the administration of this extract they were able not only to revive comatose animals, on the verge of death from suprarenal insufficiency, but also to restore them to a normal condition and to keep them in perfect health by daily injections.

The significance of such an announcement and the interest aroused by the possibility of using this extract in clinical medicine are obvious. An extensive experience in the use of the so-called Muirhead regimen in cases of Addison's disease has convinced us of the futility of ordinary therapeutic measures in combating the crises of acute suprarenal insufficiency which develop in the course of this disease and of the great need for a more active cortical preparation which can be administered either hypodermically or intravenously. This point was further emphasized by a patient with Addison's disease who was brought to the hospital in a state of complete collapse, May 31, 1930. The outlook seemed hopeless under ordinary conditions, but as a last resort a telegram was sent to Drs. Swingle and Pfiffner and they forwarded a supply of cortical extract by air mail. The patient, who was in a state of typical collapse, was restored to activity within two to three days. A summary of the clinical history in this case follows:

The patient was a farmer, aged thirty-nine years, and first came to the clinic in January, 1930. He had had pleurisy with effusion eleven years previously and symptoms of Addison's disease had been present for eight months. He was in a critical state when admitted; he was in collapse, the systolic blood pressure was 78 mm of mercury, and the blood urea 48 mg for each 100 cc. Treatment was given with solutions of sodium chloride and glucose intravenously, and the Muirhead regimen was instituted. The patient improved slowly; he was dismissed from the hospital thirty-nine days after admission.

Progress at home on the Muirhead regimen was satisfactory for a while, but the patient was brought back to the clinic in a state of collapse, May 31. Treatment

with solutions of sodium chloride and glucose was instituted again, with only partial success. The extract of the suprarenal cortex sent by Drs. Swingle and Pfiffner arrived on the sixth day after the patient's admission to the hospital and treatment was begun with daily doses of 20 cc given subcutaneously. Within thirty-six hours a marked effect on appetite and strength was apparent. The patient, who had been so nauseated as to retain water with difficulty, now asked for wieners and sauerkraut and in lieu of the latter ate a double order of beefsteak with relish.

This extract produced considerable local irritation at the site of injection and because of the content of epinephrine could not be given intravenously in therapeutic doses. A further supply of the extract was not available at that time; therefore the patient was put back on the Muirhead regimen. He did well for a few weeks, but gradually failed and again went into collapse, from which the timely arrival of a fresh supply of extract sufficed to insure temporary recovery.

This cycle has been repeated three times in this case. The last time it was possible to use Swingle and Pfiffner's newest extract, which is free from epinephrine. This was given intravenously in divided doses in a quantity of 20 cc daily with a total dosage of 50 cc. Before its use the patient was excessively weak, bedridden, depressed, nauseated, losing weight and showed evidence of failing circulation. Within forty-eight hours he had taken a new lease on life, his appetite was excellent, his strength was greatly improved and he appeared to be in a state of perfect health. He gained 9 pounds in weight in the next eight days and has been in good condition since then.

Since that time it has been possible to observe the effect of the preparation on three other patients suffering from Addison's disease. The condition of one patient was not considered serious at the time of his examination and he was kept on the treatment for only four days. There were no spectacular changes during this period and the small supply of extract precluded its further trial. In the other two cases the clinical condition of the patients and the results obtained by treatment were similar in character to those observed in the first case. Metabolism studies were made in one case during the period of observation. The results will be reported later, but preliminary observations indicate disappearance of creatinuria and retention of nitrogen in consequence of the administration of the suprarenal extract.

The results in these cases convince us of the apparent efficacy of this cortical extract. There was no striking change in the blood pressure, but the disappearance of anorexia, increase of appetite to the point of hunger, the gain in weight and the definite feeling of increased strength and well-being were striking. As long as the preparation was administered, the results were all that could be desired. However, our supply of the preparation has been limited, so that we have not been able to observe the results following consistent dosage and continued administration. The first preparation was not free from epinephrine and caused local irritation when given subcutaneously. The later supply, however, is almost free from epinephrine; it is suitable for intravenous administration and is almost non-irritating locally. As has been shown, the immediate results in a crisis were excellent. Addison's disease, however, is chronic, and it will be necessary for several years to elapse before a final appraisal can be made of the value of this new therapeutic agent in its treatment.

LEONARD G. ROWNTREE
CARL H. GREENE

DIVISION OF MEDICINE,
THE MAYO CLINIC,
ROCHESTER, MINNESOTA

THE suprarenal cortical extract used intravenously by Dr. Rowntree on patients with Addison's disease represents the modification of our original aqueous preparation mentioned in an earlier communication to this journal.[1] This extract, 1 cc of which represents 30 gm of fresh beef cortex, contains only 0.3 per cent. of solids. The epinephrine content as measured by blood pressure assay on dogs is at most between 1:1,000,000 and 1:2,000,000. The method of fractionation used is based on our observation that, by the proper use of permutit, epinephrine can be practically quantitatively separated from the cortical hormone. The 70 per cent. alcohol-soluble fraction obtained by our previously described method[2] is simply filtered in alcoholic solution through an adequate amount of permutit which removes the epinephrine. Much inert material including most of the contaminating pigment is also removed by this fractionation step.

W. W. SWINGLE
J. J. PFIFFNER

PRINCETON UNIVERSITY AND
BIOLOGICAL LABORATORY,
COLD SPRING HARBOR, L. I.

## ON THE CHEMICAL ALTERATION OF PURIFIED ANTIBODY-PROTEINS

DIAZONIUM salts of well-defined chemical compounds coupled to proteins have been used in the study of the relation of biological specificity to chemical constitution, in particular by Landsteiner[1] and his coworkers in the last two decades. It has usually been found that the coupled compound fully determines the

[1] SCIENCE, 72: 75–76, 1930.
[2] SCIENCE, 71: 321–322, 1930.
[1] Landsteiner and Lampl, *Biochem. Zeitschrift*, 86: 343, 1930.

specificity of these proteins as antigens, but some experiments have been published in which the original biological specificity of the proteins also remains.[2]

It would seem possible, therefore, to alter chemically with the same methods such substances as display a specific biological activity without destroying this latter quality. This process appeared to us of special interest in the case of animal proteins, which play an important rôle in pathology because they carry the immune properties of the animal body, namely, the antibodies. The antibodies have a specific affinity towards their antigens (pathologic bacteria) but they usually do not destroy them or do not even lower their resistance enough to permit them to be phagocytized. We thought that in some instances a chemical alteration of the type mentioned above might increase the destructive effect of antibodies on pathogenic antigens and convert these antibodies into a quasi specific disinfectant or chemotherapeutic agent. We are attempting to obtain such an effect by introducing groups to change the physical properties of the immunebody-carrier proteins, or groups which are known to possess disinfecting or chemotherapeutic activity, or known to be apt to increase the disinfecting power of organic disinfectants.

Experimental work along this line was started in these laboratories some months ago, and without knowledge of the somewhat similar experiments and results which were recently published by Bronfenbrenner.[3] In view of the accordance of our findings (with respect to the fact that chemical alteration, if carefully conducted, does not destroy immune properties) with his (presumably using different agents) a preliminary report upon some phases of our work would seem to be in order.[4]

In certain of our experiments para-aminophenylarsonic acid (atoxyl) was used for diazo-coupling because of its activity as a chemotherapeutic agent in certain protozoan diseases. The antibody protein was a Type I and II pneumococcus antibody, for this can be prepared in a comparatively highly purified state and its strength can be measured more easily than that of any immune serum produced against a protozoan parasite. The diazotization was carried out in the usual way. However, the pH was not allowed to change during the whole process of coupling more than from 5.0 to 7.5, approximately. A product resulted which was almost insoluble around its isoelectric point at pH 6, and soluble to a dark brown solution at neutral or alkaline reaction, soluble with a light yellow color on the acid side of the isoelectric point. This "antibody-dye" could easily be reprecipitated by dialysis and adjustment of pH. On carrying out the process in the same way a second time, identical products were apparently obtained, the $As_2O_3$/N ratio being in one case 0.028, in the other 0.027. If the products were taken up in the same volume of physiological saline as the original, agglutination was observed up to the same dilution as with the original antibody preparation (1/320). A very marked prezone was found, which was not present in the original preparation. Mice infected with 100,000 lethal doses of virulent pneumococci could be protected fully, *i.e.*, cured with 0.2 cc of the preparation containing respectively 6.6 mg N and 0.18 mg $As_2O_3$, and 7.5 mg N and 0.2 mg $As_2O_3$ per cc, when injected intravenously, simultaneously with the infection, or 4 hours after, or 20 hours after the infection. Normal horse serum-globulin coupled with atoxyl had almost no effect. It is also interesting to note that 0.5 cc of the original antibody solution killed mice almost instantly when injected intravenously, whereas the same amount of the coupled product had no effect.

Finally, we also note that the introduction of the easily detectable arsenic into the antibody-carrier protein is helpful for quantitative study of the degree of purification of antibodies, as well as quantitative study of the antibody reaction. Further experiments are in progress.

L. REINER

THE BURROUGHS WELLCOME AND COMPANY
EXPERIMENTAL RESEARCH LABORATORIES,
TUCKAHOE, NEW YORK,
AND THE LITTAUER RESEARCH LABORATORY,
NEW YORK UNIVERSITY

[2] A. Klopstock and C. E. Selter, *Zeitschrift für Immunitäts.*, 55: 118, 1928; M. Heidelberger and F. E. Kendall, *Proc. Soc. Exp. Biol. Med.*, 26: 482, 1929.

[3] Bronfenbrenner, *Proc. Soc. Exp. Biol. Med.*, 28: 734, 1930.

[4] Bronfenbrenner's object in starting his experiments was different from the above. He wanted to deprive immune sera of their original biological specificity in order to avoid anaphylactic shock at repeated injections of sera derived from the same species.

## BOOKS RECEIVED

CARDAN, JEROME. *The Book of My Life.* Translated from the Latin by Jean Stoner. Pp. xvii + 331. Dutton. $3.50.

COULTER, JOHN M., CHARLES R. BARNES and HENRY C. COWLES. *A Textbook of Botany.* Volume I, Morphology. Pp. viii + 310. 618 figures. Volume II, Physiology. Pp. viii + 307. 87 figures. Revised editions. American Book Company. $2.60 complete.

CULVER, CHARLES A. *Electricity and Magnetism.* Pp. vii + 383. 241 figures. Macmillan. $3.25.

LEWIS, HARRY F. *Fundamentals of Organic Chemistry.* Pp. viii + 390. 28 figures. McGraw-Hill. $2.75.

REED, H. D., and B. P. YOUNG. *Laboratory Studies in Zoology.* Pp. viii + 121. McGraw-Hill. $1.00.

ROLLESTON, SIR HUMPHRY. *Internal Medicine.* Pp. ix + 92. Hoeber. $1.50.

SCHLESINGER, H. I. *General Chemistry.* Revised edition. Pp. xi + 847. 47 figures. Longmans, Green. $4.00.

TIMM, JOHN A. *An Introduction to Chemistry:* A Pandemic Text. Pp. xviii + 561. 160 figures. McGraw-Hill. $3.50.